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A REPORT ON BACTERIAL POLLUTION AFFECTING SHELLFISH HARVESTING IN NEWPORT RIVER, NORTH CAROLINA

Environmental Protection Agency
Athens, Georgia

April 1972

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U.S. Environmental Protection Agency
Region IV
Surveillance and Analysis Division
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INTRODUCTION

At the request of the North Carolina Office of Water and Air Resources, Carteret County Environmental Resources Commission, and concerned citizens, a joint study involving the Environmental Protection Agency and U. S. Public Health Service Food and Drug Administration was conducted to determine the sources of bacterial pollution in freshwater and estuarine portions of the Newport River (Figures 1 and 1A).

The Newport River is an important shellfish producing area, some of which has been closed to shellfish harvesting since October 1969. The first closure in this area coincided with a by-pass of untreated municipal wastes from the Newport, North Carolina, sewage treatment plant. Following this action, the State Health Department, Division of Shellfish Sanitation, instituted a rather intensive bacteriological monitoring program of the growing area. Since that time, the monitoring has shown the total coliform bacterial quality of the growing waters to generally violate the USPHS standards(1) for shellfish harvesting.

Unfortunately, the bacterial quality of these growing areas prior to the 1969 closure cannot be as extensively evaluated as is possible since 1969 because a shortage of bacteriological data exists. The paucity of available data prior to initial closure prevents an accurate assessment of the historical quality of these areas with regard to the established USPHS standards and hinders a true assessment of the full impact of the treatment plant by-pass.

Coliform bacteria have traditionally been used as indicators of fecal contamination in water quality investigations. Coliform bacteria are always present in the intestines of warm-blooded animals and are discharged in large numbers in their excreta. Presence of large numbers of coliform bacteria in

a water is generally indicative of fecal pollution and is likewise indicative of the possible presence of enteric pathogens and viruses.

This report is concerned with the levels of bacterial indicators in the Newport River estuary and tributaries and, where possible, identification of the probable sources of the indicators. Conclusions are drawn and recommendations presented as to means of controlling bacterial contamination in the Newport estuary.

Water quality in the immediate shellfish growing areas was evaluated by the USPHS study and the findings reported in a separate publication. The study area included in the USPHS study is depicted in Figure 1A.

SUMMARY AND CONCLUSIONS

SUMMARY

1. Portions of the Newport River have been closed to shellfish harvesting since 1969 due to excessive levels of coliform bacteria in the growing waters. Closure of the area to shellfish harvesting coincided with a by-pass of untreated domestic wastes from the town of Newport, North Carolina.

2. The Newport River, from its source to Little Creek Swamp, is classified for fishing (Class C) by the North Carolina Office of Water and Air Resources. Streams tributary to the river in this reach carry a similar classification. The bacterial criteria in Class C waters (log mean of 1,000 fecal coliform/100 ml) was not violated at any sampling site during the study.

3. The Newport River downstream from Little Creek Swamp and including Little Creek Swamp and Mill Creek are classified for shellfishing (Class SA). This classification requires compliance with the USPHS Standard (median total coliform not to exceed 70/100 ml and not more than 10 percent exceed an MPN of 230/100 ml). Each station located within the Class SA waters was in violation of the established criteria during the study period.

4. The major domestic waste source discharging directly into the Newport River within the study area is the Newport sewage treatment plant (STP). This plant discharged an estimated 123,000 gpd with a mean (geometric) total and fecal coliform density of 64 and 22/100 ml, respectively. These mean densities were measured during a 24-hour period when the plant was chlorinating its effluent.

5. The Newport STP had removal efficiencies of 72 percent for suspended solids, 83 percent for BOD_5, and greater than 99.99 percent for both total and fecal coliform bacteria. These efficiencies were determined during a 24-hour period when the plant was chlorinating its effluent.
6. The West Carteret High School activated sludge and sand filtration treatment plant discharged an estimated 6,200 gpd (on week days) of treated wastes containing a mean total and fecal coliform density of 30 and 23/100 ml, respectively, into a small ditch tributary to the Newport River.
7. Sludge deposits extend approximately 100 yards downstream from the Newport STP outfall. These deposits are characterized by high organic carbon (7.6 - 13.7 percent), high organic nitrogen (0.40 - 0.80 percent) concentrations, and visible grease and sewage solids.
8. Of the tributaries entering the Newport River, Deep Creek had the highest mean total and fecal coliform densities, 4,000 and 680/100 ml, respectively, followed by Hull Swamp with mean total and fecal coliform densities of 3,600 and 410/100 ml, respectively.
9. Time of travel from the Newport STP outfall through "The Narrows" was approximately 43 hours as determined by a dye study. River flow was average during the period of dye passage.
10. Salmonella were isolated at five main stem river stations. Four serotypes were identified; these were: S. bredeney, S. reading, S. anatum, and S. muenchen.
11. A soil sample collected at an authorized septic tank disposal site, located off U.S. Highway 70, was analyzed. Mean total and fecal

coliform densities were >2,400,000 and 110,000/gram of soil, respectively. A minimum of 79,000 Escherichia coli, Variety I/gram of soil was recovered.

12. A controlled 22-hour curtailment of chlorination at the Newport STP resulted in the discharge of mean total and fecal coliform densities of 9,700,000 and 2,300,000/100 ml, respectively. During the non-chlorinated period, indicator densities in the Newport River were elevated.

CONCLUSIONS

1. During the December 1971 study period, excessive coliform levels in the shellfish growing areas of the Newport River were not attributable to waste discharges from the Newport STP or the West Carteret High School waste treatment facility. If these two treatment plants operate continuously as they operated during this study (excluding the chlorine cut-off phase), their wastes discharges will not pose an immediate threat to the shellfish growing areas.
2. Major improvements of the physical plants have been made at the Newport STP and the West Carteret High School STP enabling both facilities to more effectively reduce bacterial densities in their final effluents.
3. The majority of the coliform population contributed to the upper Newport River estuary is introduced from tributary streams and sources incidental to the river shore. Of the tributaries sampled above "The Narrows," Deep Creek and Hull Swamp contribute the largest number of coliforms. Wildlife common to these areas, together with agricultural runoff, serve as major sources of coliform contamination within the watershed.
4. Increased chloride concentrations (425 - 7020 mg/l) at high tide in the lower portion of the river (Stations 7 through 12) increased bacterial die-off in this portion of the river.

5. The concentration of septic tanks in the unincorporated areas of the watershed, especially those installed in areas unsuited for adequate operation, have the potential for contributing bacterial pollution to the Newport River and tributary streams.
6. The land disposal of septic tank cleanings onto some approved "disposal sites" in the Newport River watershed, along with clandestine discharge of such cleanings, have the potential for contributing tremendous bacterial densities to receiving streams during periods of runoff.
7. Fecal coliform to fecal streptococci ratios, where applicable, suggest that pollution in the lower portion of the river is primarily of animal origin (wild and/or domestic) and not readily controllable.
8. Presence of sludge deposits in the vicinity of the Newport STP outfall are indicative of previous discharges of inadequately treated or untreated municipal wastes.
9. The elevation in indicator levels between Stations 1N and 1S and Station 2 cannot be totally attributed to the Newport STP discharge. The additional indicators entering the river from tributary streams within this reach account for some portion of the increased indicator levels. Similarly, downstream of the Newport STP, natural bacterial contamination from Deep Creek, Snows Swamp Branch, and Hull Swamp has a greater impact on bacterial quality of the river than does the STP discharge.
10. The Newport STP, because of its design and proximity to the shellfish growing waters, requires a higher order of continuity in operator attention than presently received to assure the maximum degree of treatment possible at all times.

11. A bacteriological surveillance of the Newport STP should be planned and implemented by an appropriate state agency. Such a program would serve both as a means of determining treatment efficiency and as a warning mechanism for possible plant malfunctions.

12. Although the West Carteret High School waste treatment facility appears to be an insignificant contributor of bacterial contamination to the Newport River, some consideration should be given to a bacteriological and chlorine residual surveillance of this waste source.

RECOMMENDATIONS

1. For the ultimate protection and preservation of the Newport River as an economic asset through shellfish harvesting, serious consideration must be given to a regional waste collection and treatment approach. Such an approach should have as its objective the removal of all industrial and municipal waste discharges from the Newport estuary. This approach coupled with judicious land zoning and development within the Newport River watershed may well determine the future of shellfish harvesting in this area.
2. The North Carolina Office of Water and Air Resources should establish a program under which the bacterial quality of the Newport sewage treatment plant effluent will be determined at frequent intervals. This could be a joint effort with the Division of Shellfish Sanitation.
3. The Newport sewage treatment plant must maintain the maximum degree of treatment and disinfection of its waste discharge at all time. In order to accomplish this, the following measures are considered essential:
    - In-plant improvements already initiated must be completed without delay (see page 15).
    - The completion of a permanent four-day raw waste storage lagoon, fine solids settling basin and additional chlorination facilities (including automatic change-over equipment) should progress without delay.
    - The present treatment plant operator should be relieved of other duties and be required to immediately monitor and maintain plant operation on a full-time basis.

- Adequate chlorination practices should be continued and the frequency of residual chlorine determinations increased.

4. Any treatment plant malfunction that may result in the discharge of high bacterial densities must be brought to the immediate attention of the North Carolina Office of Water and Air Resources and Division of Shellfish Sanitation in order that appropriate action can be initiated.

5. The current procedures for land disposal of wastes resulting from septic tank cleaning should be abandoned and properly located and adequate disposal areas and/or facilities be provided for such wastes. Strict regulations for proper disposal of such wastes should be promulgated and enforced by appropriate county and state authorities.

6. Additional sanitary surveys are needed to better define those wastes sources affecting the Newport River. These surveys should give special attention to the role that tributary streams play in discharging bacterial pollutants to the estuary.

7. Future lowland drainage efforts along the Newport River must be carefully evaluated as to their potential as transporters of not only surface run-off but also associative bacterial contamination. In many instances drainage efforts magnify bacterial contamination in streams and result in a deterioration of stream quality.

AUTHORITY

The U. S. Environmental Protection Agency study of the Newport River was performed at the request of the Office of Water and Air Resources for the State of North Carolina. Authority for such studies is contained in Section 5(a) of the Federal Water Pollution Control Act as amended (33 USC 466 et. seq.).

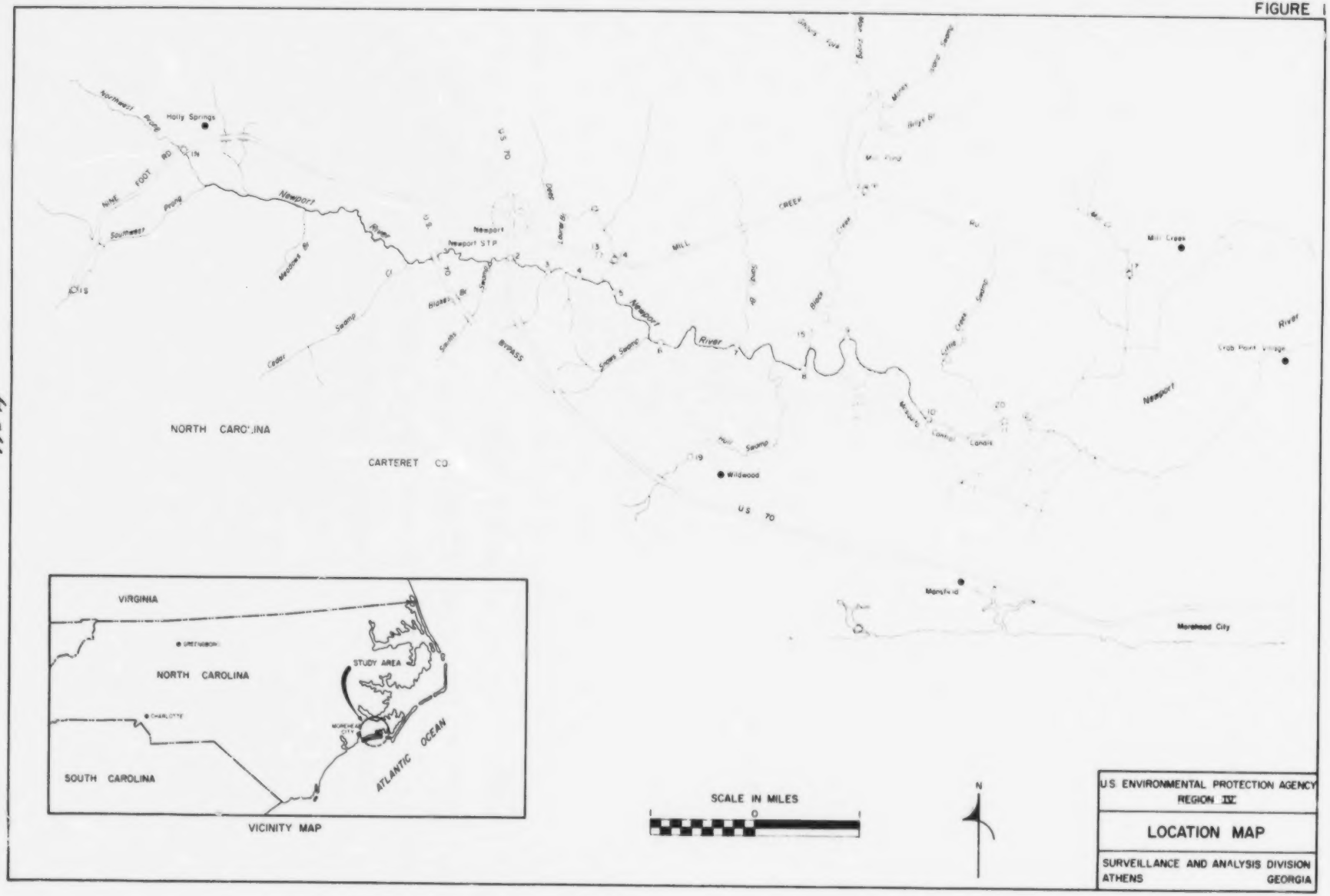
STUDY AREA

The EPA study area included the Newport River from its source to a point approximately 0.2 mile downstream from "The Narrows." Streams tributary to the Newport River within this area were included in the study area (Figure 1). Sampling station locations are shown in Figure 1 and descriptions of the stations are contained in Table I.

The Newport River is located entirely within Carteret County, North Carolina. The river is formed by the confluence of the Northwest and Southwest Prongs, flows generally in an easterly direction, and empties into the Atlantic Ocean. The Newport River and tributaries within the study area flow through predominantly forested and agricultural lands. The river is bordered by a swamp-like zone, some of which is inundated at high tide. The river is influenced tidally to a point upstream from the town of Newport.

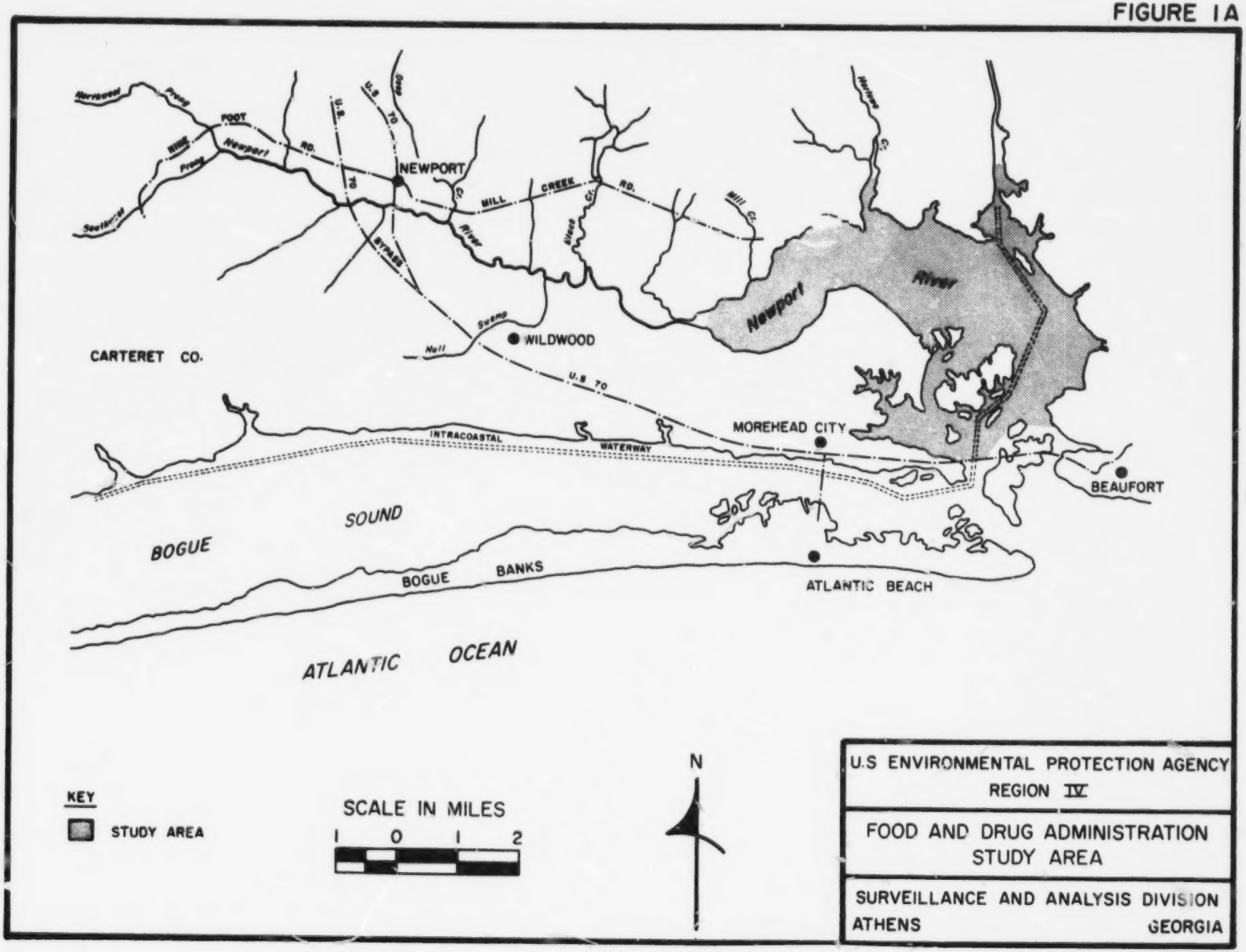
The study area included in the USPHS study is depicted in Figure 1A.

FIGURE 1


Holly Springs
Northwest Prong
Nine Foot
Southwest Prong
Newport
River
Newport STP
Meadow Br
Blades Br
Cedar
Swamp
Smith
BYPASS
Slocum Swamp
Newport
River
Mill
Creek
Mill Creek
Crab Point Village
Newport
NORTH CAROLINA
CARTERET CO.
Wildwood
US 70
Morehead City
VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA
STUDY AREA
ATLANTIC OCEAN
VICINITY MAP
SCALE IN MILES
0
N
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV
LOCATION MAP
SURVEILLANCE AND ANALYSIS DIVISION
ATHENS GEORGIA

11-A

FIGURE 1A



II-B

TABLE I

Station Locations

Station	Description
1N	Northwest Prong at Nine Foot Road Bridge
1S	Southwest Prong at Nine Foot Road Bridge
2	Newport River at U. S. Highway 70 Bridge
3	Newport River at Atlantic and East Carolina Railroad Trestle
4	Newport River 0.3 mile upstream from the mouth of Deep Creek
5	Newport River 0.2 mile downstream from the mouth of Deep Creek
6	Newport River 0.1 mile downstream from the mouth of Snows Swamp Branch
7	Newport River 0.5 mile upstream from the mouth of Hull Swamp
8	Newport River 0.3 mile downstream from the mouth of Hull Swamp
9	Newport River 1.1 miles downstream from Station 8
10	Newport River 0.8 mile upstream from Station 11
11	Newport River 0.1 mile upstream from the mouth of Little Creek Swamp
12	Newport River 0.1 mile downstream from the mouth of Little Creek Swamp
13	Drainage canal parallel to Mill Creek Road 0.1 mile west of Deep Creek
14	Deep Creek at Mill Creek Road Bridge
15	Black Creek 0.1 mile upstream from the confluence with the Newport River
16	Black Creek at the Mill Pond overflow at Mill Creek Road Bridge
17	Mill Creek at the Mill Creek Road Bridge
19	Hull Swamp at the Atlantic and East Carolina Railroad Trestle
20	Little Creek Swamp 0.1 mile upstream from its confluence with the Newport River

WATER QUALITY STANDARDS

The Newport River from its source to Little Creek Swamp is classified as Class C waters by the State Board of Water and Air Resources. The Northwest Prong, Southwest Prong, Deep Creek, Hull Swamp, and Black Creek from their sources to the Newport River are also classified as Class C waters.

The bacterial standards applicable for Class C waters are that fecal coliform bacteria are not to exceed a log mean of 1,000/100 ml (MPN or MF) based upon at least five consecutive samples examined during any 30-day period; nor exceed 2,000/100 ml in more than 20 percent of the samples examined during such period.(2)

The Newport River from Little Creek Swamp to a line across Newport River from a point of land at the northside of the mouth of Calico Creek to Gallant Point is classified for shellfishing as Class SA waters. Little Creek Swamp and Mill Creek from their sources to the Newport River are also classified for shellfishing.

The bacterial standard for Class SA waters is that the total coliform bacteria group are not to exceed a median MPN of 70/100 ml, and not more than 10 percent of the samples shall exceed an MPN of 230/100 ml for a 5-tube decimal dilution test in those areas most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions.(2)

WASTE SOURCES

There are two major point sources of sanitary wastes within the EPA study area. These are the town of Newport, North Carolina, sewage treatment plant, and the West Carteret High School waste treatment facility.

The town of Newport has a population of 1,735 and is served by a secondary (activated sludge) sewage treatment plant. This plant has an average estimated flow of 123,000 gpd with post-chlorination. The plant discharges directly into the Newport River.

The West Carteret High School is served by a package extended aeration secondary treatment plant following by sand filtration and post-chlorination. The plant discharged an estimated 6,200 gpd into a ditch which connects with a network of mosquito control drainage ditches draining into the Newport River.

Other sources of wastes within the study area consist of runoff from forested, agricultural cropland, and livestock grazing areas. Small concentrations of livestock, primarily swine, within the watershed serve as indirect contributors of fecal wastes to the Newport River. Wildlife common to the forested and marsh areas adjacent to the river also serve as direct and indirect contributors of fecal wastes to the Newport River.

An estimated 18,000 persons in Carteret County rely on septic tanks for domestic waste disposal.[3] Many septic tanks exist in areas which are not capable of receiving domestic wastes. Instances exist where septic tanks have been installed within the flood plain of the Newport River. The concentration of septic tanks within the watershed, together with the problem of inadequately operating septic tanks, pose a potential pollution problem not only for the Newport River and tributary streams but also have the potential for polluting shallow ground water within the area.

An associative problem with septic tank operations in the area is that of septic tank maintenance, i.e., cleaning. Such maintenance results in removal and disposal of cleanings, hopefully at approved sites within Carteret County. These sites generally consist of fields where the wastes are spread over the surface and disked into the soil. However, numerous unconfirmed reports of septic tank wastes being dumped outside these approved areas have been noted. Wastes discharged onto some of the approved sites and those clandestinely discharged have a potential during periods of runoff to enter the streams within the watershed.

MODIFICATIONS OF NEWPORT AND WEST CARTERET HIGH SCHOOL SEWAGE TREATMENT PLANTS

The town of Newport has made numerous improvements in operating procedures and physical facilities of their sewage treatment plant since 1969. These improvements were suggested and supervised by the Office of Water and Air Resources. Since 1969 the town has:

- Implemented continuous chlorination of the effluent. The chlorination program includes monitoring and manual chlorination back-up system using HTH (high test hypochlorite).
- Installed a power failure alarm system connected to the operator's home.
- Sealed an influent by-pass line to prevent any possible manual by-pass of untreated wastes.
- Replaced the sludge drying bed underdrainage line originally draining to the final effluent with a sump-pump arrangement to return these wastes to the influent wet-well.
- With assistance from Carteret County, a temporary raw waste storage pond with a four-day holding capacity has been constructed. The influent and effluent lines from this lagoon are connected to the plant wet-well to prevent any manual by-pass to the receiving stream. Recent heavy rains damaged the pond's dikes.1/
- Placed a stand-by generator at the plant to provide emergency power in cases of power failure.
- Reported power, chlorine, mechanical failures and all by-passes to the Office of Water and Air Resources by monthly report.

1/ Funding under PL 660 has been resolved to add as permanent facilities, a four-day raw-waste storage lagoon, a fine solids settling basin, and an additional chlorine contact chamber for post-chlorination.

Since 1969, Carteret County has made significant improvements at the West Carteret High School treatment plant. These improvements consisted of:

- The construction of a large sand filter following treatment and a post-chlorination contact chamber following sand filtration.

STUDY FINDINGS

BACTERIAL RESULTS

Coliform Bacteria

Newport Sewage Treatment Plant

The Newport STP effluent was sampled on five different days during the study period. The sampling was done at low tide when the outfall line was above the water level of the river. The means [1/] for the samples collected were 180 total coliforms/100 ml, 18 fecal coliforms/100 ml and 46 fecal streptococci/100 ml.

In addition, two 24-hour studies were conducted on the plant to determine: a) the bacterial removal efficiency of the plant with post-chlorination, b) the bacterial removal efficiency of the plant without post-chlorination, and c) the impact of unchlorinated, treated sewage upon the bacterial quality of the Newport River and in particular on the quality of waters in the shellfish growing areas.

During the 24-hour study with normal chlorination, the mean influent total and fecal coliform densities were 55,000,000 and 7,400,000/100 ml, respectively (Table II). The mean effluent total and fecal coliform densities were 64 and 22/100 ml, respectively. Both the total and fecal coliform removal efficiencies for the study period exceeded 99.99 percent.

Chlorination of the effluent was discontinued for a 22-hour period and the plant sampled as described in Appendix A. The mean influent total and fecal coliform densities were 24,000,000 and 7,000,000/100 ml, respectively (Table II). The mean effluent total and fecal coliform densities were 9,700,000

[1/] Geometric mean - all means referred to in the report are geometric means.

TABLE II

COLIFORM DATA - NEWPORT SEWAGE TREATMENT PLANT - DECEMBER, 1971

NON-CHLORINATED PERIOD						CHLORINATED PERIOD					
	Influent			Effluent			Influent			Effluent	
Time	Total Coliforms/ 100 ml*	Fecal Coliforms/ 100 ml*	Time	Total Coliforms/ 100 ml*	Fecal Coliforms/ 100 ml*	Time	Total Coliforms/ 100 ml*	Fecal Coliforms/ 100 ml*	Time	Total Coliforms/ 100 ml*	Fecal Coliforms/ 100 ml*
1500-1800	35,000,000	7,900,000	1500-1600	>240,000	>240,000	1300-1600	35,000,000	24,000,000	1300-1400	80	<20
1900-2200	160,000,000	14,000,000	1700-1800	7,900,000	2,300,000	1700-2000	160,000,000	3,300,000	1500-1600	490	20
2300-0200	24,000,000	7,900,000	1900-2000	17,000,000	1,700,000	2100-2400	49,000,000	11,000,000	1700-1800	<20	<20
0300-0600	35,000,000	4,900,000	2100-2200	24,000,000	3,300,000	0100-0400	28,000,000	7,900,000	1900-2000	50	<20
0700-1000	7,900,000	7,900,000	2300-2400	35,000,000	4,900,000	0500-0800	160,000,000	4,900,000	2100-2200	80	<20
1100-1200	4,800,000	3,500,000	0100-0200	24,000,000	3,300,000	0900-1200	22,000,000	4,900,000	2300-2400	<20	<20
			0300-0400	4,900,000	2,300,000				0100-0200	20	<20
			0500-0600	7,900,000	1,300,000				0300-0400	<20	<20
			0700-0800	17,000,000	1,700,000				0500-0600	<20	<20
			0900-100	7,000,000	7,000,000				0700-0800	<20	<20
			1100-1200	24,000,000	4,900,000				0900-1000	330	20
									1100-1200	1,300	50
Maximum	160,000,000	14,000,000		35,000,000	7,000,000		160,000,000	24,000,000		1,300	50
Minimum	4,800,000	3,500,000		>240,000	>240,000		22,000,000	3,300,000		<20	<20
Average	44,000,000	7,700,000		15,000,000	2,900,000		76,000,000	9,300,000		200	23
Geometric Mean	24,000,000	7,000,000		9,700,000	2,300,000		55,000,000	7,400,000		64	22

* MPN Values

17.9

and 2,300,000/100 ml, respectively. The total and fecal coliform removal efficiencies were 59.6 and 67.1 percent, respectively, for the sampling period.

West Carteret County High School Sewage Treatment Plant

The West Carteret County High School Sewage Treatment Plant effluent was sampled during school hours on two consecutive days. Samples were collected hourly, and on the second day the samples were composited every two hours. The mean effluent total and fecal coliform densities for the two days were 30 and 23/100 ml, respectively (Appendix B). Approximately 73 percent of the total coliform counts and 91 percent of the fecal coliform counts were less than 20/100 ml for the sampling period.

Newport River and Tributaries

The effect of indicator bacteria from tributaries and other wastes sources on the bacterial quality of the Newport River was much more evident when samples collected on low tide were analyzed separately. Samples were collected at low tide on five different days during the study. Most tributary stations were also sampled on low tide to avoid the effect of wastes being moved upstream at high tide.

Low Tide (Excluding Chlorine Cutoff Samples)

The low tide bacterial data were separated into counts not influenced by chlorine cutoff and counts reflecting the effect of chlorine cutoff. Due to tidal influences and sampling times, the sampling dates used to separate the data varied at different stations. The effects of chlorine cutoff are seen at Stations 2 through 7 on December 7, 1971; Stations 6

through 9 on December 8, 1971; Stations 8 through 12 on December 9, 1971; and Stations 10 through 12 on December 10, 1971 (Appendix B). The low tide data, excluding counts influenced by the chlorine cutoff are contained in Table III and are depicted in Figure 2.

Two background sampling stations on the Northwest and Southwest Prongs were selected to reflect the bacterial quality of water entering the Newport River unaffected by point sources of waste. Station 1N, on the Northwest Prong, had a low tide mean total and fecal coliform bacteria density of 230 and 140/100 ml, respectively (Table III). Station 1S, on the Southwest Prong, had a mean total and fecal coliform bacteria density of 450 and 100/100 ml, respectively. The bacterial densities at the background stations indicated some fecal pollution possibly originating from the wildlife population found in the Croatan National Forest. In Figures 2 through 7, the background stations data are combined into one background point.

Station 2, located approximately 3.5 miles downstream from the confluence of the two Prongs and 0.3 mile downstream from the Newport sewage treatment plant outfall, had a mean total and fecal coliform bacteria density of 990 and 260/100 ml, respectively (Figure 2). The increased bacterial levels at this station reflect not only the effect of the sewage treatment plant effluent but also additional contamination introduced from tributary streams downstream of the control stations.1/ At Station 3 the total coliform density decreased while the fecal coliform bacteria density remained approximately the same as Station 2. At Station 4

1/ Current bacteriological surveillance data collected by the Office of Water and Air Resources at Highway 70 by-pass and Station 2 support this observation.

TABLE III

SUMMARY OF COLIFORM AND FECAL STREPTOCOCCI DATA IN THE NEWPORT RIVER AT LOW TIDE
EXCLUDING COUNTS RESULTING FROM CHLORINE CUTOFF - DECEMBER, 1971

	Total Coliform Bacteria/100 ml*					Fecal Coliform Bacteria/100 ml*					Fecal Streptococci/100 ml**				
Sta.	Max.	Min.	Aver-age	Geo. Mean	No. of Samples	Max.	Min.	Aver-age	Geo. Mean	No. of Samples	Max.	Min.	Aver-age	Geo. Mean	No. of Samples
1N	490	110	270	230	4	490	50	200	140	4	700	100	290	230	4
1S	790	230	510	450	4	170	80	120	100	4	630	<20	190	77	4
2	1,700	330	1,300	990	4	490	80	320	260	4	480	80	200	150	4
3	2,300	490	1,500	730	4	490	220	290	280	4	720	100	290	210	4
4	3,300	400	1,800	1,400	4	330	110	230	210	4	620	120	270	220	4
5	7,900	790	2,900	1,900	4	460	130	310	280	4	380	150	280	260	4
6	3,100	790	1,900	1,600	3	460	130	310	270	3	380	160	250	230	3
7	2,300	490	1,300	1,000	3	230	170	210	210	3	640	280	460	440	3
8	3,300	1,300	2,600	2,400	3	790	170	400	310	3	940	280	530	460	3
9	4,900	1,300	2,500	2,000	3	230	110	160	150	3	620	280	450	430	3
10	4,900	1,700	3,000	2,700	3	790	270	460	410	3	780	240	510	460	3
11	7,900	1,300	5,400	4,200	3	700	70	370	250	3	560	200	380	350	3
12	3,300	1,300	2,300	2,100	3	790	490	660	650	3	740	400	530	510	3

* MPN/100 ml
** Membrane filter count/100 ml

FIGURE 2
MEAN COLIFORM AND FECAL STREPTOCOCCI DENSITIES IN THE NEWPORT RIVER AT LOW TIDE
EXCLUDING COUNTS RESULTING FROM CHLORINE CUTOFF

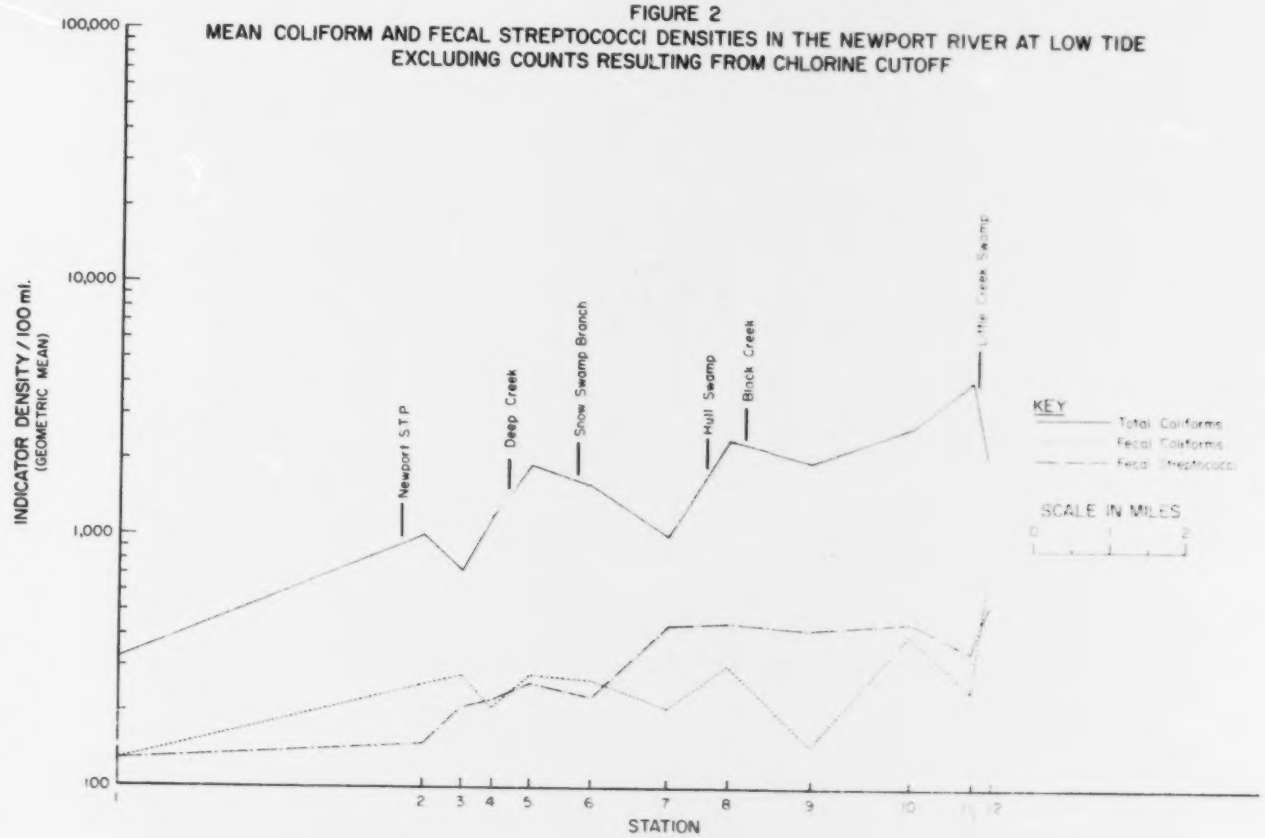
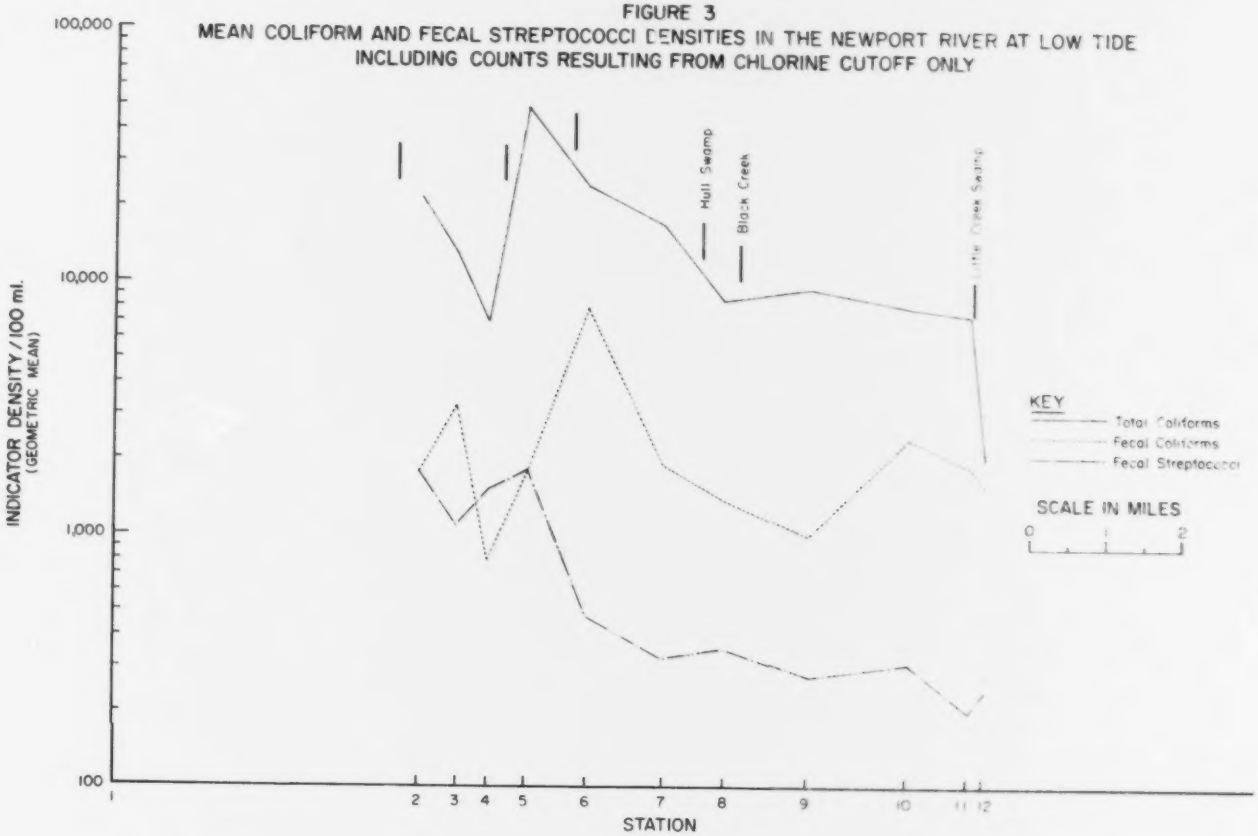


FIGURE 3
MEAN COLIFORM AND FECAL STREPTOCOCCI DENSITIES IN THE NEWPORT RIVER AT LOW TIDE
INCLUDING COUNTS RESULTING FROM CHLORINE CUTOFF ONLY



the mean total coliform bacteria density increased to 1,400/100 ml, while the mean fecal coliform bacteria density decreased to 210/100 ml indicating a die-off of some of the fecal coliform bacteria.

Approximately 0.3 mile downstream from Station 4, Deep Creek flows into the Newport River with mean total and fecal coliform bacteria densities of 4,000 and 680/100 ml, respectively (Table IV). The impact of the indicators entering from Deep Creek is seen at Station 5, located 0.2 mile downstream from the mouth of the creek. The mean bacterial densities at this station were 1,900 total coliforms/100 ml and 280 fecal coliforms/100 ml (Table III).

At Station 6 the indicator densities decreased only slightly; while further downstream a reduction of total and fecal coliforms occurred as evidenced by respective densities of 1,000 and 210/100 ml at Station 7.

Hull Swamp flows into the Newport River 0.5 mile downstream from Station 7. At Station 19, located on Hull Swamp approximately 2.0 miles above its confluence with the river, the mean total and fecal coliform bacteria densities were 3,600 and 410/100 ml, respectively (Table IV). The mean total and fecal coliform bacteria densities increased to 2,400 and 310/100 ml, respectively, at Station 8, located 0.3 mile downstream from the mouth of Hull Swamp (Figure 2). These increased levels indicated additional contamination is introduced to the river from Hull Swamp.

Black Creek flows into the river 0.2 mile downstream from Station 8. Black Creek originates at the overflow from Mill Pond. Station 16, located immediately downstream from Mill Pond overflow had a mean total and fecal coliform bacteria density of 200 and 24/100 ml, respectively, indicating little fecal pollution (Table IV). The low tide mean total and fecal coliform bacteria densities at the mouth of the creek (Station 15) were 670 and 240/100 ml, respectively (Table IV). Black Creek did not have a detrimental

TABLE IV

Summary of All Low Tide Coliform and Streptococci Data - December 1971

	Total Coliform Bacteria/100 ml*					Fecal Coliform Bacteria/100 ml*					Fecal Streptococci/100 ml**				
Sta.	Max.	Min.	Aver-age	Geo. Mean	# of Samples	Max.	Min.	Aver-age	Geo. Mean	# of Samples	Max.	Min.	Aver-age	Geo. Mean	# of Samples
1N	490	110	270	230	4	490	50	200	140	4	700	100	290	230	4
1S	790	230	510	450	4	170	80	120	100	4	630	<20	190	77	4
2	22,000	330	5,300	1,800	5	1,700	80	640	370	5	1,800	80	520	250	5
3	13,000	490	3,800	2,100	5	3,300	220	890	450	5	1,100	100	450	290	5
4	7,000	400	2,600	1,700	5	800	110	340	270	5	1,500	120	520	320	5
5	49,000	790	12,000	3,700	5	1,700	130	590	400	5	1,800	150	580	390	5
6	170,000	790	36,000	4,700	5	79,000	130	16,000	1,000	5	1,000	160	390	310	5
7	35,000	490	9,400	3,200	5	2,200	170	900	500	5	760	140	460	390	5
8	22,000	1,300	6,600	4,000	5	2,300	170	860	560	5	940	280	470	420	5
9	13,000	1,300	5,500	3,800	5	1,300	110	510	340	5	620	200	390	360	5
10	13,000	1,700	5,400	4,100	5	3,300	230	1,300	830	5	780	240	430	390	5
11	7,900	1,300	6,200	5,300	5	2,200	70	1,000	570	5	560	140	310	280	5
12	4,900	790	2,500	2,100	5	3,300	490	1,200	930	5	740	200	410	370	5
13	24,000	1,300	7,400	4,000	5	790	170	480	410	5	9,500	260	2,300	840	5
14	7,900	2,300	4,700	4,000	5	2,300	330	880	680	5	7,400	220	1,900	720	5
15	4,900	130	1,400	670	5	4,900	70	1,100	240	5	640	100	290	220	5
16	4,900	<20	1,100	200	5	50	<20	26	24	5	800	<20	260	78	5
17	2,300	790	1,400	1,300	5	1,400	330	760	680	5	950	160	510	400	5
19	1 . 90	490	6,700	3,600	5	1,400	130	560	410	5	1,700	160	800	590	5
20	3,300	230	1,300	870	5	1,300	80	450	250	5	460	40	230	170	5

* MPN/100 ml.

** Membrane filter count/100ml.

effect on the bacterial quality of the river as measured at Station 9, located 0.9 mile downstream from the mouth of the creek. The mean bacterial densities at this station were 2,000 total coliform/100 ml and 150 fecal coliform/100 ml (Figure 2).

Station 10 had a mean total and fecal coliform bacteria density of 2,700 and 410/100 ml, respectively. Station 10 is bordered by an extensive marsh area, some of which has a network of drainage canals. The marsh area may serve as a source of fecal contamination from animals residing in this habitat.

Station 11 had a mean total and fecal coliform bacteria density of 4,200 and 250/100 ml, respectively. There was an increase in the total coliform density and a corresponding decrease in fecal coliform levels at this station.

Immediately downstream of Station 11, Little Creek Swamp enters the river with a mean total and fecal coliform density of 610 and 140/100 ml, respectively. Station 12, located downstream of Little Creek Swamp, had a mean total and fecal coliform density of 2,100 and 650/100 ml, respectively. The reduction in total coliform density and the corresponding increase in fecal coliform density at this point cannot be explained (Figure 2).

Low Tide (Samples Influenced by Chlorine Cutoff)

Chlorination at the Newport Sewage Treatment Plant was discontinued from 1410 hours on 12/6/71 until 1200 hours on 12/7/71. Chlorination was discontinued to determine the impact of the unchlorinated treated sewage on the bacterial quality of the Newport River, especially in the shellfish growing areas in the lower portion of the river. The upper stations (Stations 2 through 5) had elevated indicator densities for only one day. Stations 6 through 12 had elevated indicator densities for two days because of the

tidal influence upon the river. Table V contains the data summary and Figure 3 illustrates the impact of the unchlorinated effluent on the river. A comparison of Figures 2 and 3 shows the chlorine cutoff increased mean indicator densities at the river stations from 43 to 96 percent, with one exception. The mean total coliform densities at Station 12 were comparable for both the chlorinated and non-chlorinated low tide periods, indicating a diminished impact resulting from dilution and die-off as the waste travels downstream.

Low Tide (All Samples)

Table IV contains all mean low tide data, and Figure 4 depicts these data. A comparison of all low tide data to those not affected by chlorine cutoff (Figures 2 and 4) shows generally higher indicator levels when all samples are considered. This results from the higher indicator levels measured during the chlorine cutoff period.

In comparing Figure 4 to Figure 2, it should be noted that the increased indicator levels at Station 6 resulted from a single day's high value associated with the controlled chlorine cutoff rather than from a waste source as it appears to be in Figure 4. In addition, when all the low tide data are combined, the detrimental effect of Hull Swamp on the bacterial quality of the river was masked somewhat.

High Tide

High tide has a significant effect on the bacterial quality of the Newport River (Table VI and Figure 5). The cumulative effects of dilution and the bactericidal action from the saltwater are evident at Stations 8 through 12. The bacterial densities decrease with the increasing chloride concentrations at the lower river stations during high tide (Figures 5 and 6).

TABLE V

SUMMARY OF COLIFORM AND FECAL STREPTOCOCCI DATA IN THE NEWPORT RIVER AT LOW TIDE, INCLUDING COUNTS RESULTING FROM CHLORINE CUTOFF ONLY - DECEMBER, 1971

Sta.	Total Coliform Bacteria/100 ml[1/]		Fecal Coliform Bacteria/100 ml[1/]		Fecal Streptococci/100 ml[2/]	
	Average	Geo. Mean	Average	Geo. Mean	Average	Geo. Mean
2	-	22,000[3/]	-	1,700[3/]	-	1,800[3/]
3	-	13,000[3/]	-	3,300[3/]	-	1,100[3/]
4	-	7,000[3/]	-	800[3/]	-	1,500[3/]
5	-	49,000[3/]	-	1,700[3/]	-	1,800[3/]
6	87,000	24,000	40,000	7,900	620	480
7	21,000	17,000	2,000	1,900	450	330
8	13,000	8,500	1,500	1,400	370	360
9	10,000	9,500	1,000	1,000	290	280
10	9,000	8,000	2,500	2,400	310	310
11	7,500	7,400	2,000	1,900	210	200
12	2,800	2,000	2,000	1,600	240	240

1/ MPN/100 ml
2/ Membrane filter count/100 ml
3/ Only one count

TABLE VI

Summary of All High Tide Coliform and Streptococci Data - December 1971

Sta.	Total Coliform Bacteria/100 ml*					Fecal Colifrom Bacteria/100 ml*					Fecal Streptococci/100 ml**				
	Max.	Min.	Aver-age	Geo. Mean	# of Samples	Max.	Min.	Aver-age	Geo. Mean	# of Samples	Max.	Min.	Aver-age	Geo. Mean	# of Samples
1N	2,300	230	1,200	860	4	490	80	190	140	4	600	60	290	220	4
1S	1,300	490	820	770	4	490	80	240	200	4	1,200	180	620	490	4
2	3,300	220	1,800	1,000	5	2,300	80	590	250	5	2,000	400	970	770	5
3	3,300	790	1,800	1,600	5	1,100	130	350	240	5	2,200	380	920	750	5
4	2,300	330	1,500	1,000	5	1,300	70	500	290	5	2,400	220	970	740	5
5	13,000	1,300	4,400	3,000	5	2,200	170	670	400	5	2,100	480	1,000	880	5
6	54,000	1,700	14,000	4,700	5	1,100	130	480	380	5	2,200	620	1,100	960	5
7	7,900	1,300	4,800	4,100	5	1,300	220	610	500	5	1,600	680	1,000	990	5
8	7,900	1,300	3,000	2,300	5	490	80	360	290	5	1,100	380	710	670	5
9	2,300	310	890	670	5	330	20	160	100	5	900	20	390	200	5
10	490	80	240	190	5	80	<20	50	46	5	170	20	110	87	5
11	330	80	160	140	5	50	<20	34	32	5	100	<20	66	58	5
12	1,100	50	320	170	5	50	<20	42	40	5	120	20	66	56	5
13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
15	1,700	1,100	1,400	1,400	4	490	230	300	280	4	1,100	600	750	730	4
16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
19	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
20	1,100	230	520	450	5	230	20	110	83	5	330	20	180	100	5

* MPN/100 ml.

** Membrane Filter count/100 ml.

FIGURE 4
MEAN COLIFORM AND FECAL STREPTOCOCCI DENSITIES IN THE NEWPORT RIVER
ALL LOW TIDE SAMPLES

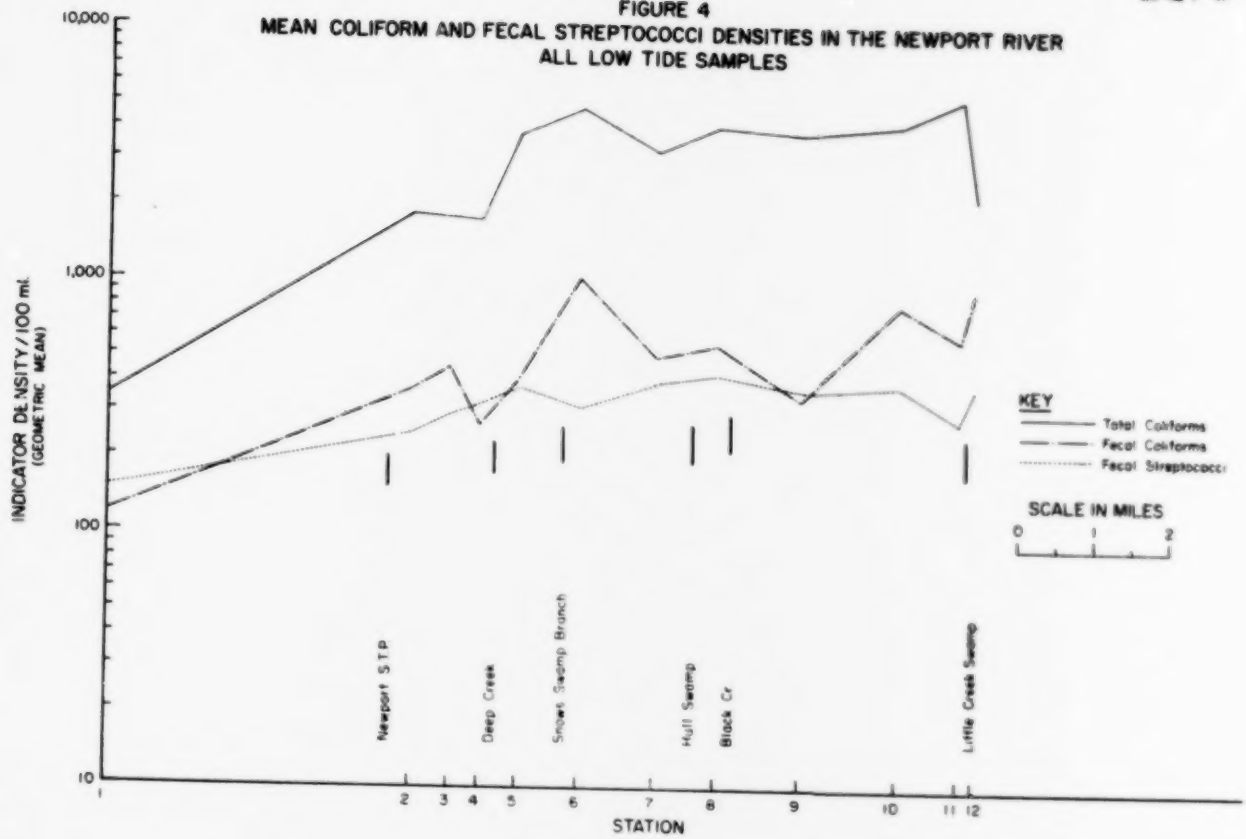
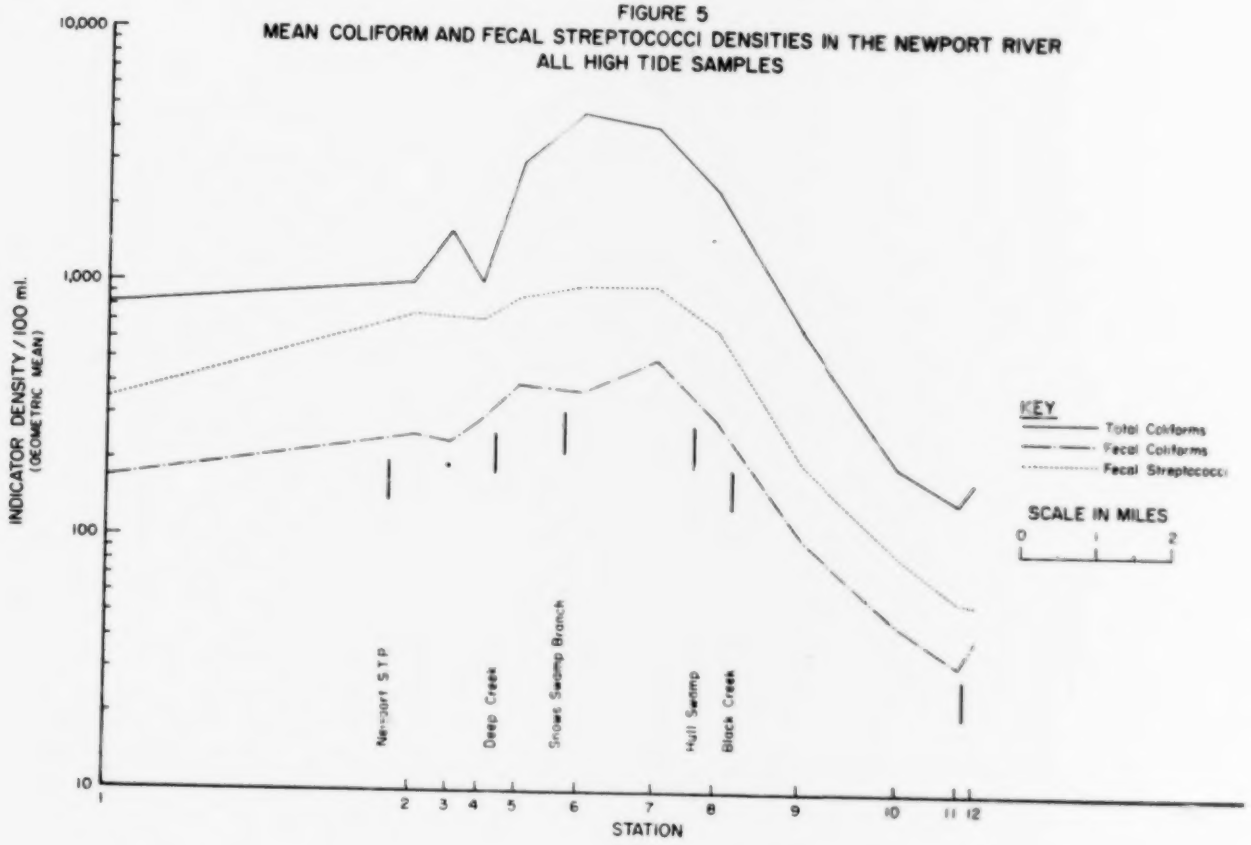


FIGURE 5
MEAN COLIFORM AND FECAL STREPTOCOCCI DENSITIES IN THE NEWPORT RIVER
ALL HIGH TIDE SAMPLES



All Samples

Table VII contains the summary for all samples collected, and Figure 7 depicts these data. Figure 7 shows the overall bacterial quality of the river for the entire study period.

As shown, the indicator levels increase in the river downstream of the control stations and Station 2 located downstream of the Newport STP. This elevation in indicator densities cannot be totally attributed to the Newport STP discharge. Additional indicators enter the river between the control stations and the Newport STP from tributary streams within this reach of stream. The cumulative effect of additional indicators entering the river from Deep Creek, Snows Swamp Branch, Hulls Swamp, and other sources appear more significant than the Newport STP discharge. This is particularly evident when the low tide data are examined (Figures 2 and 4).

Fecal Streptococci

Fecal streptococci analyses were performed to aid in establishing the origin of fecal pollution in the Newport River. It has been found that fecal coliform — fecal streptococci ratios are useful in determining the origin of fecal pollution. A fecal coliform to fecal streptococci ratio of greater than 4.0 is regarded as evidence of pollution derived primarily from human origin, whereas an FC/FS ratio of 0.7 or less suggests pollution derived predominantly or entirely from livestock, wildife, and/or poultry. Ratios just below 4.0 are still suggestive of waste primarily of human origin, and ratios slightly greater than 0.7 are still suggestive of wastes of animal origin. A truly "gray-area" of interpretation is in the ratio range of 1.0 to 2.0. Application of ratios in this range should be used rather cautiously.

Any ratio must be applied in areas where the time of travel from the

TABLE VII

Summary of All Coliform and Streptococci Data - December 1971

Sta.	Total Coliform Bacteria/100 ml*					Fecal Coliform Bacteria/100 ml*					Fecal Streptococci/100 ml **				
	Max.	Min.	Average	Geo. Mean	# of Samples	Max.	Min.	Average	Geo. Mean	# of Samples	Max.	Min.	Average	Geo. Mean	# of Samples
1N	2,300	110	710	450	8	490	50	200	140	8	700	60	290	220	8
1S	1,300	230	670	590	8	490	80	180	150	8	1,200	<20	400	200	8
2	22,000	220	3,600	1,500	10	2,300	80	610	310	10	2,000	80	750	430	10
3	13,000	490	2,800	1,800	10	3,300	130	620	330	10	2,200	100	690	470	10
4	7,000	330	2,100	1,600	10	1,300	70	420	280	10	2,400	120	750	490	10
5	49,000	790	8,300	3,300	10	2,200	130	630	400	10	2,100	150	790	580	10
6	170,000	790	25,000	4,700	10	79,000	130	8,300	630	10	2,200	160	730	550	10
7	35,000	490	7,100	3,600	10	2,200	170	760	500	10	1,600	140	750	620	10
8	22,000	1,300	4,800	3,100	10	2,300	80	610	410	10	1,100	280	590	530	10
9	13,000	310	3,200	1,600	10	1,300	20	340	190	10	900	20	390	270	10
10	13,000	80	2,800	880	10	3,300	<20	660	190	10	780	20	270	180	10
11	7,900	80	3,200	860	10	2,200	<20	520	130	10	560	<20	190	130	10
12	4,900	50	1,400	600	10	1,300	<20	630	190	10	740	20	240	150	10
13	24,000	1,300	7,400	4,000	5	790	170	480	410	5	9,500	260	2,300	840	5
14	7,900	2,300	4,700	4,000	5	2,300	330	880	680	5	7,400	220	1,900	720	5
15	4,900	130	1,400	920	9	4,900	70	740	150	9	1,100	100	490	380	9
16	4,900	<20	1,100	200	5	50	<20	26	24	5	800	<20	260	78	5
17	2,300	790	1,400	1,300	5	1,400	330	760	680	5	950	160	510	400	5
19	[illegible]00	490	6,700	3,600	5	1,400	130	560	410	5	1,700	160	800	590	5
20	3,300	230	910	610	10	1,300	20	280	140	10	460	20	200	150	10

* MPN/100 ml.

** Membrane filter count/100 ml.

73.9

FIGURE 6
AVERAGE CHLORIDE CONCENTRATIONS AT NEWPORT RIVER STATIONS

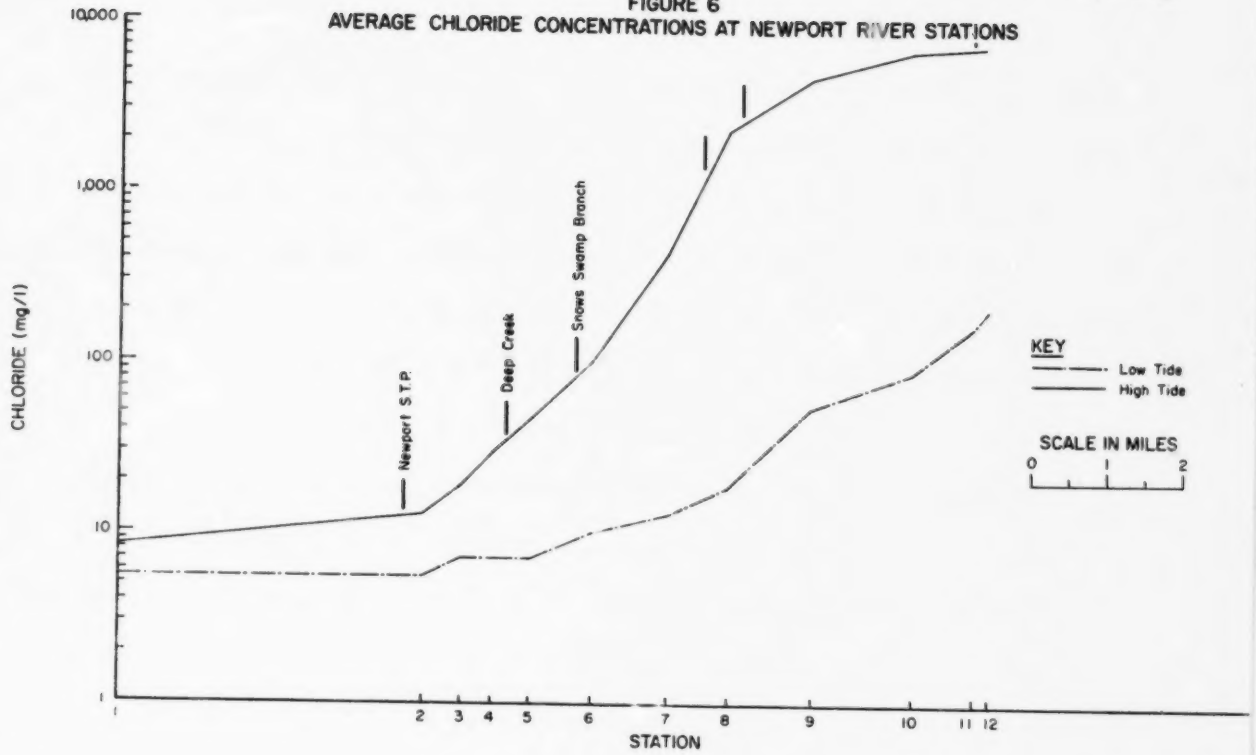
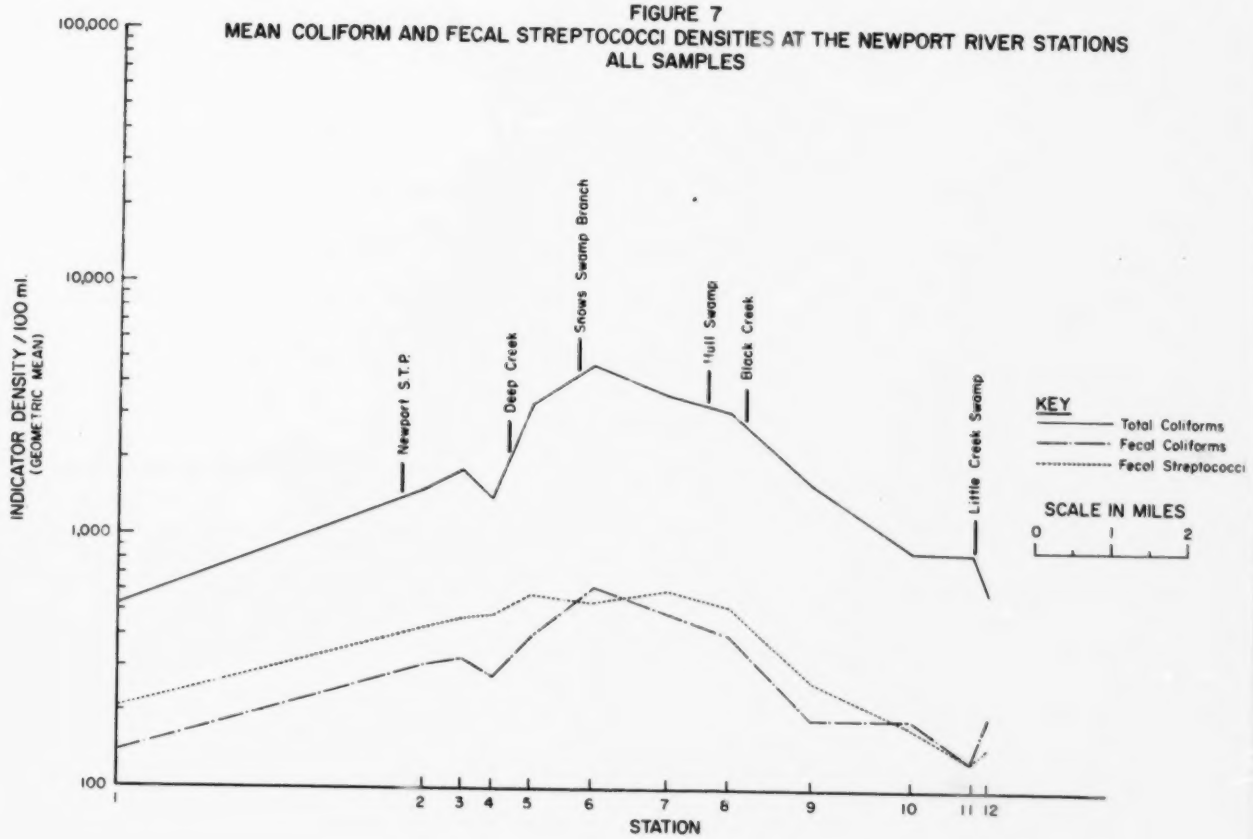


FIGURE 7
MEAN COLIFORM AND FECAL STREPTOCOCCI DENSITIES AT THE NEWPORT RIVER STATIONS
ALL SAMPLES



wastes sources to the sampling points is less than 24 hours because of the differences in die-off rates of the two bacterial groups.

Several factors complicate the interpretation of the ratios obtained during this study. Because of saltwater influences, the ratios change between high and low tide. The high tide FC/FS ratios are all 0.71 or less; however, the dilution of the freshwater and the increased die-off of the fecal coliform in saltwater complicate the ratio application.

The most lucid picture is obtained when the ratios are applied to the low tide data excluding the counts influenced by chlorine cutoff. Most of the FC/FS ratios in the lower portion of the river suggest pollution originating primarily from animal sources. The ratios in the upper portion of the river are mostly in the gray areas where no clear interpretation can be made; however, there were no ratios greater than 4.0, to indicate significant waste primarily of human origin.

Salmonella Isolation

In addition to the determinations of total and fecal coliforms and fecal streptococci, special efforts were made to detect members of the genus Salmonella at selected stations. Isolation of this pathogen at a sampling station establishes the disease-producing potential of the water and is further evidence of fecal contamination.

Attempts were made to isolate Salmonella at the background stations and all river stations.

Salmonella serotypes were isolated at Station 3 (S. bredeney) Station 5 (S. reading), Station 7 (S. muenchen), Station 9 (S. anatum), and Station 11 (S. muenchen).

Soil Sampling

A single soil sample was collected at one of the county approved septic

tank waste disposal areas located off U. S. Highway 70. The indicator densities in this soil sample were >2,400,000 total coliform/gram, and 110,000 fecal coliforms/gram. Further examination revealed that the soil contained a minimum of 79,000 Escherichia coli Variety I/gram as determined by the IMViC classification (4). These high bacterial densities indicated the grossly polluted condition of soil in the disposal area. Indications were that the disposal site had not been used for at least one week prior to sampling. The high indicator densities, together with the absence of freshly dumped wastes, indicate an abundant reservoir of total and fecal coliform bacteria within the area. The potential danger exists during times of rainfall for tremendous bacterial levels to enter nearby drainage ditches and eventually be discharged into the Newport River.

PHYSICAL AND CHEMICAL RESULTS

Newport Sewage Treatment Plant

Chemical Quality

The removal efficiencies for BOD_5 and suspended solids were determined. BOD_5 removal was approximately 83 percent and suspended solids removal was approximately 72 percent. The removal efficiencies for these parameters indicate the plant was operating at slightly less than peak efficiency during the study period.

Flow Determinations

The estimated flow during a five-day period, 12/4/71 through 12/8/71 at the Newport plant was 123,000 gpd.

Chlorine Contact Time Determination

Adequate disinfection of treated wastes is dependent on the level of residual chlorine in the effluent and the contact time between the chlorine and the wastes. Both the chlorine concentration present in the treated effluent and the contact time were determined for the Newport STP.

Hourly total residual chlorine levels of the treated wastes at the Newport STP cutoff (measured at the second manhole in the outfall line) ranged from 0.75 to 7.0 mg/l during the 24-hour period preceeding chlorine cutoff (Table VIII).

Chlorine contact time was calculated as time in the contact chamber plus additional contact time in the outfall line to the river. Rhodamine WT dye was injected into the influent line of the chlorine contact chamber, and the time for the dye peak to pass through the chamber and the time of flow in the outfall to the river were determined. The dye study data are shown in Figure 8.

TABLE VIII
TOTAL HOURLY RESIDUAL CHLORINE IN NEWPORT STP EFFLUENT *

Time	mg/l
0900	3.5
1000	3.0
1100	0.75
1200	1.0
1300	7.0
1400	7.0
1500	3.0
1600	2.0
1700	3.2
1800	4.5
1900	3.0
2000	3.7
2100	4.5
2200	4.0
2300	4.5
2400	3.7
0100	4.7
0200	7.0
0300	6.0
0400	6.0
0500	7.0
0600	7.0
0700	7.0
0800	7.0

* Measured at the second manhole in the outfall line.

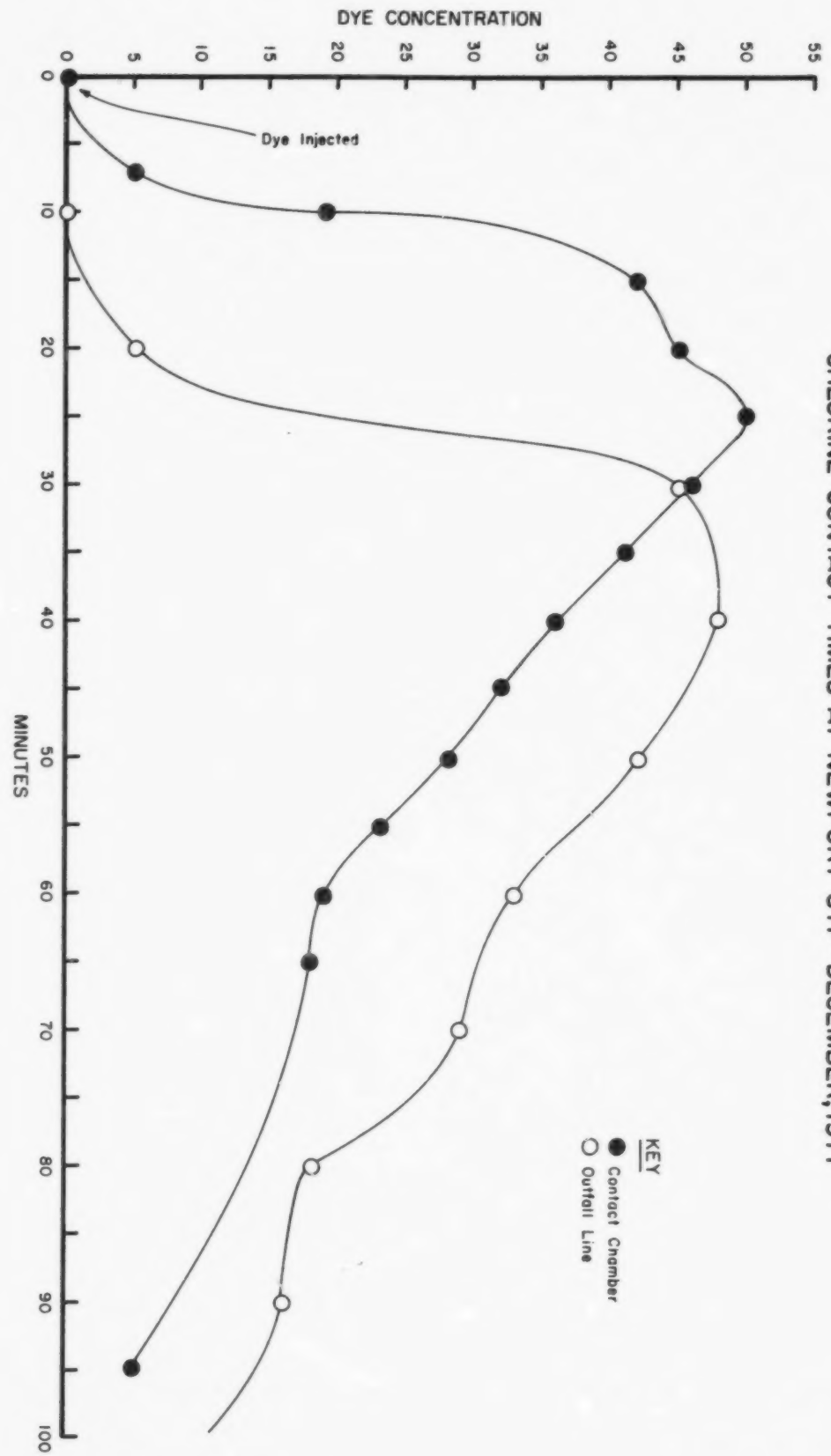


FIGURE 8
CHLORINE CONTACT TIMES AT NEWPORT STP - DECEMBER, 1971

As shown in Figure 8, the contact time (time to reach peak dye concentration)for the contact chamber was approximately 24 minutes, with a leading edge time of approximately seven minutes. An additional 15 minutes of contact time occurs in the outfall line. These data indicate the minimum contact time in the chamber and the outfall line to be approximately 20 minutes. The mean contact time at which the highest fraction of the sewage flow would be exposed was approximately 40 minutes. These contact times were determined at an average flow rate of approximately 136,000 gpd.

West Carteret High School Sewage Treatment Plant

Chemical Quality

The only chemical parameter considered was residual chlorine. The total residual chlorine levels ranged from 0.05 - 2.5 mg/l during the two-day sampling period.

Flow Determination

Effluent flow from the West Carteret plant was estimated to be 6,200 gpd.

Newport River and Tributaries

Sediment Characterization

Results of the sediment analyses are shown in Table IX. Sediment collected immediately upstream from the Newport STP outfall contained a high concentration of organic carbon (6.4 percent) and relatively low organic nitrogen level (0.3 percent). However, samples collected in the vicinity of the outfall and to a point some 0.3 mile downstream (Station 2) had even higher concentrations of organic carbon (7.6 - 13.7 percent) and high concentrations of organic nitrogen (0.40 - 0.80 percent). The high organic carbon

TABLE IX

SEDIMENT CHARACTERIZATION, NEWPORT RIVER
December, 1971

Station Location	COD mg/kg	Organic Carbon %	Organic Nitrogen mg/kg	Total Phosphorus mg/kg	Volatile Solids ppm	Percent Moisture
20 yds above Newport STP outfall	173,000	6.4	2,900	844	150,815	59.1
20 yds below Newport STP outfall	368,000	13.7	7,000	1,547	304,040	81.5
50 yds below Newport STP outfall	448,000	16.7	8,000	891	414,080	83.1
100 yds below Newport STP outfall	321,000	12.0	4,000	703	241,620	77.2
Station 2	204,000	7.6	4,000	750	167,050	73.6
Station 3	158,000	5.9	3,300	478	131,430	67.1
Station 4	162,000	6.1	3,500	595	141,690	65.4
Station 6	19,000	7.1	850	124	24,480	35.1
Station 7	14,700	5.5	2,400	308	93,780	61.5
Station 8	5,600	0.21	250	92	4,520	22.5
Station 9	4,300	0.16	400	60	7,650	24.6
Station 10	189,000	7.1	400	572	118,100	64.3
Station 11	45,000	1.7	1,100	168	43,770	48.3
Station 12	87,000	3.2	2,250	291	73,230	59.1

and organic nitrogen concentrations downstream of the outfall indicate the presence of sludge deposits of municipal sewage origin. The presence of visible grease, and other solids of sewage origin were present in the sludge deposit.

Downstream from Station 2 there was no additional evidence of sludge deposition.

Chloride Concentrations

Average surface chloride concentrations determined at each station are contained in Table X and shown in Figure 6. As shown, the maximum saltwater intrusion extends approximately four miles above the "The Narrows" at high tide. Low tide chloride concentrations in the river were extremely low except for Station 12, located in "The Narrows." All tributary chloride levels were low with the exceptions of Station 17 (Mill Creek), 20 (Little Creek Swamp), and 15 (Black Creek), where tidal influences were present.

Time of Travel Study

Results of the time of travel study from the Newport STP effluent through "The Narrows" are shown in Figure 9.

In conjunction with the chlorine cutoff study, Rhodamine dye was released at the Newport STP outfall on high slack tide. Within one-quarter hour, the tide began to ebb and downstream movement of the dye cloud observed. Downstream movement of the dye was followed both visually and with the aid of instruments. Streamflow during the time of travel study remained constant and was estimated to be approximately 34 cfs. Under these conditions, approximately 43 hours was required for passage of the dye from the Newport outfall to Station 11 (Figure 9).

The release of dye at high slack tide resulted in maximum downstream

28.4

TABLE X

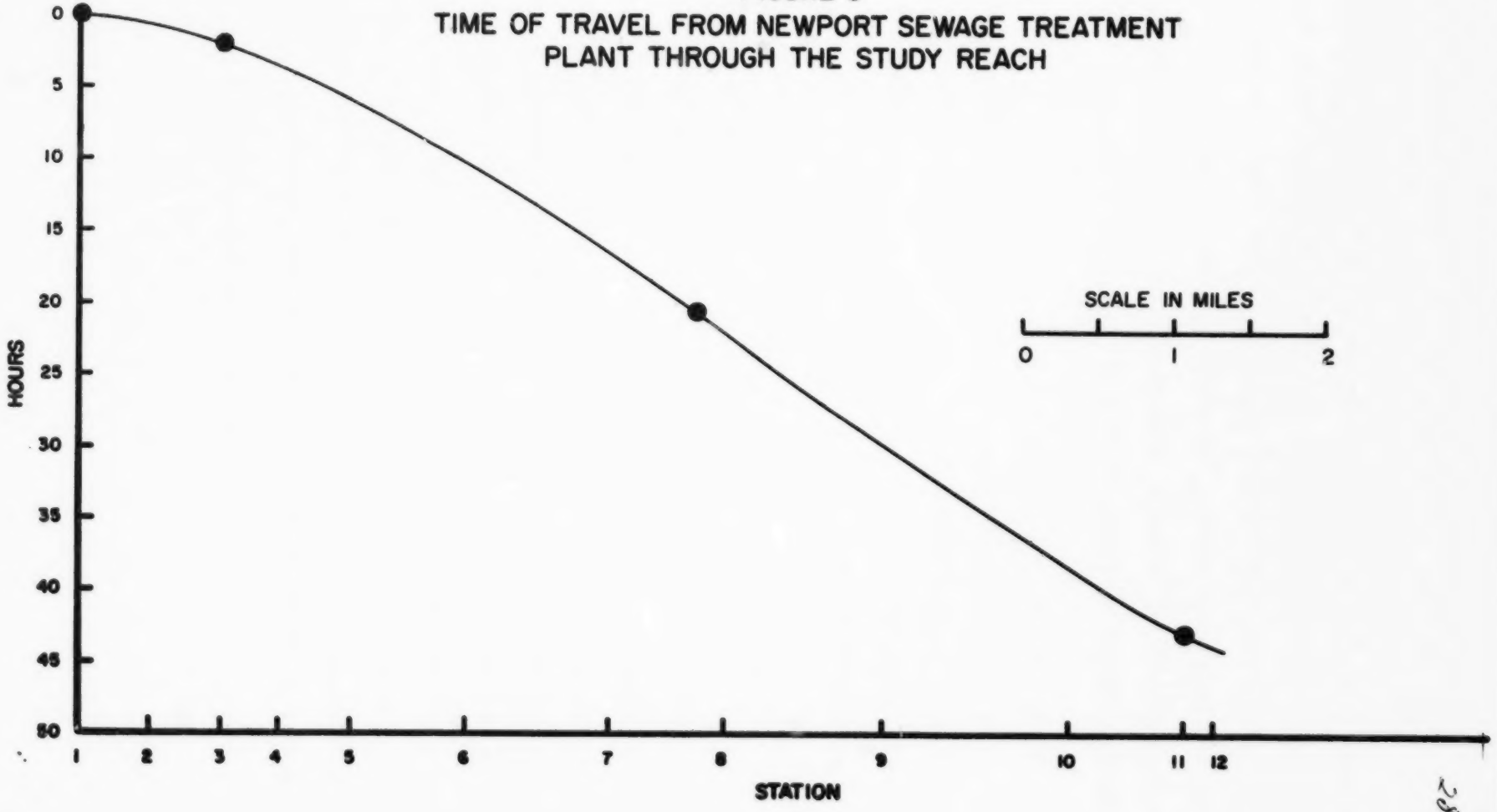
AVERAGE SURFACE CHLORIDE CONCENTRATIONS
NEWPORT RIVER AND TRIBUTARIES
December 1971

Station	High Tide mg/l	Low Tide mg/l
1*	8	6
2	13	6
3	19	7
4	29	7
5	47	7
6	101	10
7	425	13
8	2,250	19
9	4,580	54
10	6,600	86
11	6,960	159
12	7,020	202
13	11	15**
14	12	12**
15	1,900	54
16	7	7
17	1,400	3,600**
19	15	15
20	5,760	725

* Average of Stations 1N and 1S.

** Single determination.

FIGURE 9
TIME OF TRAVEL FROM NEWPORT SEWAGE TREATMENT
PLANT THROUGH THE STUDY REACH



28-B

movement during the first tidal cycle and in the shortest possible time of travel under similar flow conditions. If dye was released at low slack tide, an upstream movement would occur on the next tidal cycle and a longer time of travel would result. The additional time in such a case is estimated to be approximately 12 hours. This would result in an overall estimated time of travel of approximately 55 hours.

Flow Determinations

Flows were estimated for the Northwest and Southwest Prongs, Hull Swamp, and Deep Creek. Flows in the Northwest and Southwest Prongs were estimated to be 15.2 and 19.0 cfs, respectively. Flows in Hull Swamp and Deep Creek were estimated to be 2.9 and 15.0 cfs, respectively.

STANDARDS VIOLATIONS

River Stations 2 through 11 are located in Class C waters according to State of North Carolina. There were no bacterial standards violations at any of these river stations. Also the Northwest Prong, Southwest Prong, Deep Creek, Hull Swamp, and Black Creek are classified as Class C waters and all the stations located on these tributaries were able to meet the established bacteriological standard. Station 12, on the Newport River, was located in Class SA waters and there was a violation of the bacterial standard at this station. In addition, two stations located on Little Creek Swamp and Mill Creek which are classified as Class SA waters were in violation of the bacterial standard set for Class SA waters.

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APPENDIX A

STUDY METHODS

BACTERIOLOGICAL SAMPLING

All stream samples analyzed for indicator bacteria were collected near the surface using a grab technique. The samples were collected in sterile glass containers and placed on ice until time of analysis. Most samples were analyzed within four hours of collection.

The sampling regime was dictated by tidal conditions. Stream samples were collected at both high and low slack tide. All of the main stem stream stations were sampled five times at both high and low tides.

Stream samples collected for the purpose of isolating Salmonella were obtained using a modification of the swab technique of Moore (5). Sanitary napkins (swabs) were folded, gauze ends tied together, and a length of heavy string attached. The swabs were then wrapped in kraft paper and sterilized. The sterile swabs were suspended beneath the water surface at selected sampling stations. After three to five days, the swabs were retrieved, placed in sterile plastic bags, and returned to the laboratory for analysis.

All Newport sewage treatment plant samples analyzed for indicator bacteria were collected on an hourly basis. Hourly influent (collected after wet well and pumps) plant samples were composited every four hours and hourly effluent (second manhole in outfall line) samples were composited every two hours for 24 hours. Total residual chlorine was determined for each hourly effluent sample. All chlorinated samples were dechlorinated using sterile 10 percent sodium thiosulfate. The samples were collected in sterile glass containers and placed on ice until analysis. Most samples were analyzed within eight hours of collection.

All West Carteret High School treatment plant samples analyzed for in-

dicator bacteria were collected on an hourly basis and composited every two hours for eight hours. Only effluent samples were collected. Residual chlorine was determined for each sample collected. All samples were dechlorinated using sterile 10 percent sodium thiosulfate. All samples were analyzed within six hours of collection.

SOIL SAMPLING

A soil sample was collected at a selected site in a sterile wide mouth sample bottle using a sterile spatual to remove the soil. After collection, the sample was returned to the laboratory for analysis. Representative 10 gram portions were weighed in sterile 250 ml beakers and aseptically transferred to 90 ml dilution blanks. After thorough mixing, appropriate dilutions were made and total and fecal coliform analyses performed.

BACTERIOLOGICAL EXAMINATION

Total Coliform Enumeration: The standard coliform procedure outlined in Standard Methods (4) for the five-tube MPN multiple-tube dilution was used. The procedure employs lauryl tryptose broth incubated at 35 $\pm$ 0.5°C for 24 and 48 $\pm$ 3 hours followed by confirmation using brilliant green lactose bile broth incubated at 35 $\pm$ 0.5°C for 24 and 48 $\pm$ 3 hours.

Fecal Coliform Enumeration: The fecal coliform procedure outlined in Standard Methods (4) for the five-tube MPN multiple-tube dilution was used. The procedure employs the standard presumptive test using lauryl tryptose broth followed by fecal coliform confirmation using EC medium at an elevated temperature (44.5° $\pm$ 0.2°C waterbath) for 24 $\pm$ 2 hours.

IMViC Classification of Coliform Isolates: The IMViC reactions (indole, methyl red, Voges-Proskauer and citrate) were determined for some of the coliform isolates. These tests were performed according to Standard

Methods (4).

Fecal Streptococci Enumeration: The membrance filter technique outlined in Standard Methods (4) was used. The method employs M-Enterococcus agar incubated at 35 ± 0.5°C for 48 hours.

Salmonella Isolation and Identification: Swabs used for isolation purposes were placed into wide-mouthed jars containing approximately 200 ml of 1 1/2 strength tetrathionate broth with brilliant green added. The inoculated enrichment was incubated from 24 to 48 hours at 41.5°C according to the procedure of Spino (6). After either primary or sub-culture enrichment, an inoculum for each enrichment was streaked onto Xylose Lysine Desoxycholate Agar (XLD) and Hektoen Enteric Agar (HE) plates and incubated at 35° ± 0.5°C for 18-24 hours. Suspected Salmonella colonies were picked from the respective plates and subjected to the identification scheme outlined in Table XI.

The methods and media outlined in Table XI are described by Ewing (7), with the exception of the cytochrome oxidase method. Oxidase activity was determined using Patho-Tec-CO[1/] reagent impregnated strips.

Definitive serological identification of Salmonella isolates was made at the Southeast Water Laboratory, Athens, Georgia. The methodology used was the standard serological procedures described by Edwards and Ewing (8).

CHEMICAL SAMPLING

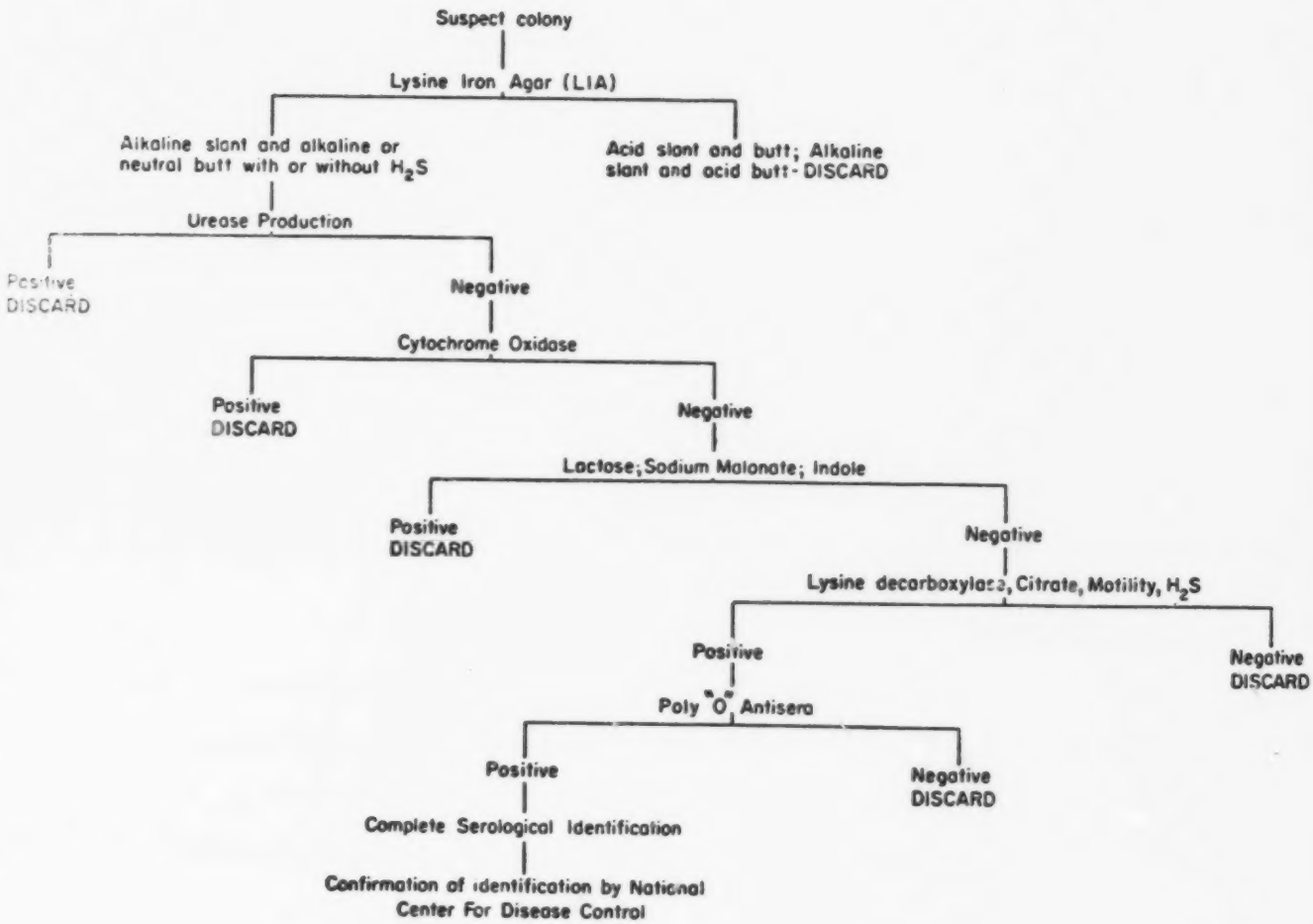
Daily stream samples were collected for chloride determinations. These samples were collected at the same depth (approximately one foot) as the bacteriological samples.

Sediment samples were collected in the vicinity of the Newport STP

1/ Does not imply endorsement of the product.

Table XI

IDENTIFICATION SCHEME FOR SALMONELLA SUSPECTS



effluent and at each main-stem river station. These samples were collected in whirl-pak bags and frozen until analysis. The parameters analyzed for were:

Parameter	Method	Reference
o Chemical Oxygen Demand	Acid-Dichromate Oxidation	4
o Volatile Solids	Gravimetric, 550°C	4
o Total Phosphorus	Automated (Ascorbic Acid)	9
o Percent Organic Carbon	Calculated from COD	10
o Percent Organic Nitrogen	Calculated	10
o Percent Moisture	Dry at 103°C	11

Hourly influent effluent samples were collected at the Newport STP (at the same points as bacteriological samples) and composited over a 24-hour period for chemical analysis. During the compositing period the samples were maintained in an iced condition. The parameters analyzed for were:

Parameter	Method	Reference
o Suspended Solids	Gravimetric, 103°C	4
o Volatile Solids	Gravimetric, 550°C	4
o Total Phosphorus	Automated (Ascorbic Acid)	9
o Organic Nitrogen	Acid Digestion, Auto-phenolate	9, 11
o Nitrite-Nitrate Nitrogen	Automated (Cadmium Reduction)	9
o Ammonia	Automated Phenolate	9
o BOD_5	Standard Method	4

FLOW DETERMINATIONS

Time of Travel: Rhodamine WT dye (20% w/v) was injected into the river at the outfall line of the Newport STP on a high slack tide. Monitoring the dye cloud movement downstream was made using a fluorometer equipped with

a continuous flow-through adapter. Time of travel is the difference between the time the dye was added to the stream and the time the peak dye concentration arrives at the selected downstream point.

Tributary Flows: Streamflows were calculated for those major tributaries where tidal influences could be precluded. Average cross-sectional measurements and average velocities were determined at several tributary streams. All measurements were made at low slack tide on those tributaries affected by the tides. On those streams not affected by tides, either staff gages were installed or tape down references established for use in flow computation.

Sewage Treatment Plant Flow: Instantaneous and average daily effluent flows were determined at the Newport STP. Flow determinations were made by setting up a stage recorder which was calibrated with two V-notch wiers located in the chlorine contact chamber. Flow determinations were made for five consecutive days.

Chlorine Contact Time: Chlorine contact time at the Newport STP was determined for both the contact chamber and additional contact time obtained in the effluent line. Rhodamine WT dye was injected into the incoming line to the contact chamber. The chlorine contact chamber effluent line and the effluent line at the point of discharge to the river were monitored for dye concentrations. Samples were collected at five-minute intervals at the chamber effluent line and at 10-minute intervals at the river outfall. Samples were collected for a period of time sufficient to characterize the total detention time.

APPENDIX B

BACTERIAL DATA FOR THE ENTIRE STUDY
DECEMBER, 1971

Station	Date	Time	Total Coliforms per 100 ml*	Fecal Coliforms per 100 ml*	Fecal Streptococci per 100 ml**
1-N	12-3-71	1130	230	80	60
	12-4-71	1236	2,300	490	600
	12-5-71	1259	1,300	110	260
	12-6-71	1455	790	80	240
	12-7-71	0930	490	490	700
	12-8-71	1003	230	130	180
	12-9-71	1110	230	130	180
	12-10-71	1133	110	50	160
1-S	12-3-71	1140	790	230	180
	12-4-71	1243	700	490	1,200
	12-5-71	1307	1,300	170	470
	12-6-71	1502	490	80	610
	12-7-71	0940	230	130	630
	12-8-71	1010	700	170	70
	12-9-71	1120	790	90	40
	12-10-71	1140	330	80	<20
2	12-1-71	--	1,700	490	480
	12-2-71	1132	220	170	760
	12-3-71	1112	1,700	80	400
	12-4-71	1225	3,300	2,300	1,400
	12-5-71	1230	700	260	2,000
	12-6-71	1402	3,300	130	310
	12-7-71	0846	22,000	1,700	1,000
	12-8-71	0921	1,300	220	90
	12-9-71	1030	1,300	490	80
	12-10-71	1100	330	80	140
3	12-1-71	--	2,300	490	720
	12-2-71	1128	790	130	380
	12-3-71	1110	1,100	130	500
	12-4-71	1206	1,700	170	740
	12-5-71	1223	3,300	1,100	2,200
	12-6-71	1359	2,300	230	800
	12-7-71	0836	13,000	3,300	1,100
	12-8-71	0917	1,100	230	230
	12-9-71	1027	2,300	220	100
	12-10-71	1055	490	230	120

* MPN

** Membrane filter.

BACTERIAL DATA FOR THE ENTIRE STUDY (cont'd)
DECEMBER, 1971

Station	Date	Time	Total Coliforms per 100 ml*	Fecal Coliforms per 100 ml*	Fecal Streptococci per 100 ml**
4	12-1-71	--	790	130	440
	12-2-71	1125	330	230	600
	12-3-71	1105	1,300	70	220
	12-4-71	1204	2,200	130	900
	12-5-71	1222	1,300	790	2,400
	12-6-71	1356	2,300	1,300	750
	12-7-71	0834	7,000	800	1,500
	12-8-71	0915	3,300	330	190
	12-9-71	1025	1,700	310	120
	12-10-71	1052	400	170	160
5	12-1-71	--	1,700	490	620
	12-2-71	1120	1,300	170	700
	12-3-71	1100	3,300	170	480
	12-4-71	1201	3,300	490	1,000
	12-5-71	1220	13,000	2,200	2,100
	12-6-71	1354	1,300	330	750
	12-7-71	0830	49,000	1,700	1,800
	12-8-71	0913	7,900	310	150
	12-9-71	1023	1,300	130	300
	12-10-71	1050	790	330	280
6	12-1-71	--	1,700	460	380
	12-2-71	1115	1,700	130	820
	12-3-71	1055	1,300	330	620
	12-4-71	1157	7,900	330	920
	12-5-71	1215	54,000	1,100	2,200
	12-6-71	1348	2,300	490	810
	12-7-71	0827	170,000	79,000	1,000
	12-8-71	0910	3,300	790	230
	12-9-71	1020	3,100	340	160
	12-10-71	1045	790	130	200
7	12-1-71	--	2,300	170	640
	12-2-71	1110	7,900	1,300	680
	12-3-71	1050	1,300	220	740
	12-4-71	1153	4,900	490	1,200
	12-5-71	1212	4,900	330	1,000
	12-6-71	1342	4,900	700	1,600
	12-7-71	0823	7,900	1,700	760
	12-8-71	0905	35,000	2,200	140
	12-9-71	1015	1,100	220	460
	12-10-71	1040	490	230	280

* MPN
** Membrane filter.

BACTERIAL DATA FOR THE ENTIRE STUDY (cont'd)
DECEMBER, 1971

Station	Date	Time	Total Coliforms per 100 ml*	Fecal Coliforms per 100 ml*	Fecal Streptococci per 100 ml**
8	12-1-71	--	3,300	790	940
	12-2-71	1105	1,300	490	720
	12-3-71	1045	1,300	80	380
	12-4-71	1150	2,300	230	540
	12-5-71	1209	7,900	490	800
	12-6-71	1336	2,300	490	1,100
	12-7-71	0819	3,300	230	380
	12-8-71	0900	22,000	2,300	460
	12-9-71	1010	3,300	790	280
	12-10-71	1035	1,300	170	280
9	12-1-71	--	4,900	110	460
	12-2-71	1055	790	230	160
	12-3-71	1015	330	20	20
	12-4-71	1113	700	110	140
	12-5-71	1154	310	110	750
	12-6-71	1319	2,300	330	900
	12-7-71	0804	1,300	230	620
	12-8-71	0844	13,000	1,300	380
	12-9-71	1006	7,000	790	200
	12-10-71	1017	1,300	140	280
10	12-1-71	--	2,300	270	780
	12-2-71	1045	490	50	140
	12-3-71	1010	80	<20	20
	12-4-71	1107	80	50	60
	12-5-71	1150	330	80	170
	12-6-71	1312	230	50	170
	12-7-71	0757	1,700	330	520
	12-8-71	0838	4,900	790	240
	12-9-71	1000	13,000	3,300	340
	12-10-71	1008	4,900	1,700	280
11	12-1-71	1300	7,000	70	380
	12-2-71	1025	110	40	100
	12-3-71	1005	80	20	<20
	12-4-71	1100	170	50	80
	12-5-71	1147	330	40	80
	12-6-71	1305	110	<20	50
	12-7-71	0753	7,900	700	560
	12-8-71	0835	1,300	330	200
	12-9-71	0956	7,000	2,200	280
	12-10-71	1000	7,900	1,700	140

* MPN
** Membrane filter.

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BACTERIAL DATA FOR THE ENTIRE STUDY (cont'd)
DECEMBER, 1971

Station	Date	Time	Total Coliforms per 100 ml*	Fecal Coliforms per 100 ml*	Fecal Streptococci per 100 ml**
12	12-1-71	1410	2,300	790	440
	12-2-71	1010	130	50	80
	12-3-71	0955	50	<20	20
	12-4-71	1050	170	50	40
	12-5-71	1140	1,100	40	70
	12-6-71	1250	130	50	120
	12-7-71	0736	3,300	700	740
	12-8-71	0825	1,300	490	400
	12-9-71	0945	4,900	3,300	280
	12-10-71	0947	790	790	200
13	12-2-71	1537	2,300	330	680
	12-3-71	1637	24,000	790	750
	12-4-71	1727	7,900	790	9,500
	12-8-71	0847	1,300	330	340
	12-9-71	1300	1,700	170	260
14	12-2-71	1540	2,300	790	460
	12-3-71	1640	4,900	330	1,000
	12-4-71	1730	4,900	2,300	7,400
	12-8-71	0855	7,900	490	220
	12-9-71	1305	2,300	490	260
15	12-1-71	--	790	330	400
	12-2-71	1100	1,100	230	600
	12-3-71	1028	--	--	--
	12-4-71	1125	1,400	230	600
	12-5-71	1159	1,400	230	700
	12-6-71	1335	1,700	490	1,100
	12-7-71	0815	130	80	640
	12-8-71	0855	330	80	100
	12-9-71	1008	790	70	180
	12-10-71	1030	4,900	4,900	120
16	12-2-71	1547	330	20	<20
	12-3-71	1647	4,900	50	800
	12-4-71	1740	80	<20	440
	12-8-71	0902	110	<20	<20
	12-9-71	1310	<20	<20	20
17	12-2-71	1555	1,300	790	820
	12-3-71	1655	2,300	790	950
	12-4-71	1748	1,300	490	480
	12-8-71	0911	790	330	160
	12-9-71	1320	1,400	1,400	160

* MPN
** Membrane filter.

BACTERIAL DATA FOR THE ENTIRE STUDY (cont'd)
DECEMBER, 1971

Station	Date	Time	Total Coliforms per 100 ml*	Fecal Coliforms per 100 ml*	Fecal Streptococci per 100 ml**
19	12-2-71	1615	490	130	440
	12-3-71	1727	17,000	1,400	1,200
	12-4-71	1702	7,900	630	1,700
	12-8-71	0830	7,000	310	480
	12-9-71	1340	1,300	330	160
20	12-1-71	1400	790	130	140
	12-2-71	1020	330	80	260
	12-3-71	1000	230	20	70
	12-4-71	1055	490	80	220
	12-5-71	1145	460	230	20
	12-6-71	1256	1,100	130	330
	12-7-71	0743	230	230	460
	12-8-71	0830	490	50	300
	12-9-71	0952	3,300	490	40
	12-10-71	0953	1,700	1,300	200
Newport	12-2-71	1600	1,100	13	420
STP	12-3-71	1630	490	20	60
Outfall	12-8-71	0930	50	<20	<20
	12-9-71	1035	330	<20	<20
	12-10-71	1105	<20	<20	<20
West Carteret High School STP	12-9-71	1000	<20	<20	
	12-9-71	1100	20	<20	
	12-9-71	1200	20	<20	
	12-9-71	1240	1,700	90	
	12-9-71	1400	<20	<20	
	12-9-71	1500	<20	<20	
	12-9-71	1600	<20	<20	
	12-10-71	0930-1000	<20	<20	
	12-10-71	1100-1200	<20	<20	
	12-10-71	1300-1400	<20	<20	
	12-10-71	1500-1600	<20	<20	

* MPN
** Membrane filter.

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